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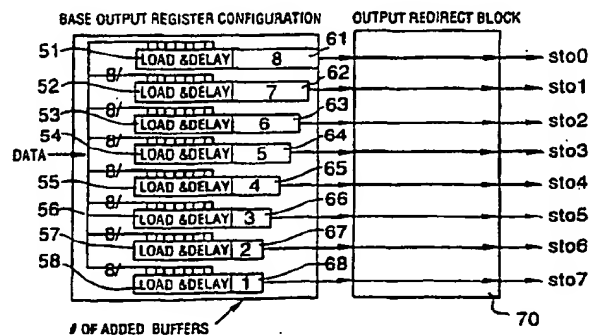
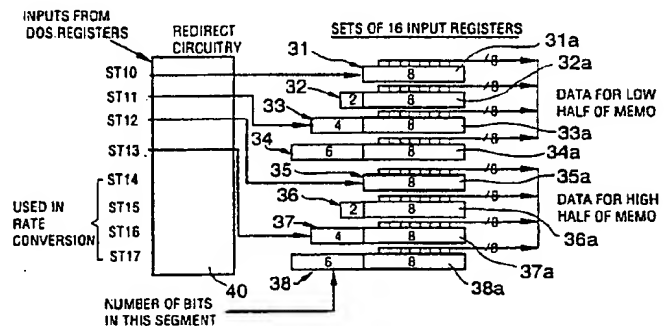
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(54) Title: SERIAL BIT RATE CONVERTER FOR A TDM SWITCHING MATRIX

(57) Abstract

A time division switching matrix capable of effecting rate conversion comprises a plurality of serial inputs for connection to respective serial input links, each capable of carrying time division multiplexed PCM channels, a plurality of serial outputs for connection to respective serial output links, each capable of carrying time division multiplexed PCM channels, and a serial-to-parallel converter associated with each input for converting a serial input stream to parallel format, each said serial-to-parallel converter being independently configurable to produce the same net parallel throughput regardless of the bit rate of the associated input link. The output side of the switching matrix can be similarly configured.



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## SERIAL BIT RATE CONVERTER FOR A TDM SWITCHING MATRIX.

This invention relates to a time division switching matrix capable of effecting rate conversion.

Many digital telephone systems are based on the  
5 transport of time multiplexed, serialized PCM (pulse  
coded modulation) encoded voice bytes. PCM is an 8 bit  
encoding scheme for digitizing an analog voice signal,  
sampled at 8 khz. Different telephone networks employ  
different degrees of multiplexing between the bytes  
10 flowing serially at a rate of 8 bits per 125 microseconds  
(the period of 8 khz.). Popular schemes include time  
division multiplexing of 32 voice channels (for a net  
data rate of 2.048 megabits per second), 64 voice  
channels (for 4.096 megabits per second) or 128 voice  
15 channels (for 8.192 megabits per second) onto single PCM  
highways.

Most if not all digital networks require switching  
between logical channels in the interconnected PCM  
highways. Hitherto this has been performed with rate  
20 conversion circuitry.

According to the present invention there is provided  
a time division switching matrix capable of effecting  
rate conversion comprising a plurality of serial inputs  
for connection to respective serial input links, each  
25 capable of carrying time division multiplexed PCM  
channels, a plurality of serial outputs for connection to  
respective serial output links, each capable of carrying  
time division multiplexed PCM channels, and a serial-to-

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parallel converter associated with each input for  
converting a serial input stream to parallel format, each  
said serial-to-parallel converter being independently  
configurable to produce the same net parallel throughput  
5 regardless of the bit rate of the associated input link.

The invention allows for rate conversion in the  
switching matrix, for example, between PCM highways of  
2.048 megabits per second, and 4.096 megabits per second,  
or 2.048 megabits per second and 8.192 megabits per  
10 second. It also allows for conversion from 8.192 megabits  
per second to 2.048 megabits per second, or 4.096  
megabits per second and 2.048 megabits per second. With  
rate conversion, networks with differing serial  
backplanes can be interconnected.

15 In the preferred embodiment, the switching core of  
the device consists of a ram based time switch that  
switches 256 x 256 channel locations. During each 125  
microsecond frame 256 bytes of incoming PCM data are  
written in sequence into a data ram. During the frame,  
20 256 reads of the same memory fetch PCM data bytes, which  
are shifted out onto serial output links. The time at  
which the fetch occurs determines the output link and  
channel number that the PCM data is to be routed to.

The invention will now be described in more detail,  
25 by way of example only, with reference to the  
accompanying drawings, in which:

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Figure 1 is a diagram showing the memory address timing for a switching matrix in accordance with the invention;

Figure 2 is a diagram showing the inputs shift  
5 registers for the 2Mb/s mode;

Figure 3 shows the input data stream redirects for the 4Mb/s mode;

Figure 4 shows the input data stream redirects for 8Mb/s mode;

10 Figure 5 shows the 2Mb/s configuration;

Figure 6 shows the output data stream redirects for the 4Mb/s mode;

Figure 7 shows the 8Mb/s timing;

Figure 8 shows the output data stream redirects for  
15 the 8Mb/s mode; and

Figure 9 is a block diagram of a switching matrix in accordance with the invention.

The switching matrix shown in Figure 9 comprises input Mux 1, 2 each containing reconfigurable shift  
20 registers and producing 8 bit parallel output on input buses 3, 4, 5, 6 connected directly to memories 7, 8, 11, 12, and through Mux 16 to memories 9,10. The memories are in turn are connected to parallel output buses 13. Output buses 13 are connected through data select switch 14 to

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output Mux 15, which is connected to eight serial output links.

The switch also includes a counter 17, a frame counter 18, an address control unit 19, and low and high  
5 memories 20, 21.

At 2.048 megabits per second input and output, the switching matrix can switch between 8 physical input links with 32 time multiplexed PCM channels and 8 output links with 32 channels. As the speed of the input  
10 (output) data rate is increased, the number of input (output) is reduced by half, and the number of channels in the active links double. The switching memory always operates with a nominal 244 nanosecond cycle time.

The multiplexing of the data memory accesses is  
15 depicted in Figure 1, in which F<sub>oi</sub> is an 8khz framing pulse and C<sub>4i</sub> is a 4.096 Mhz clock that clocks the operation of the memories

Data memory writes are doubled up, i.e. 2 PCM bytes from the serial input are written in parallel to free up  
20 clock cycles for time multiplexed memory accesses.

Within this framework of accesses to the switching matrix core, incoming serial data is converted into a parallel format in sequence, to allow for 128 writes, of two bytes each, to be performed. This is accomplished by  
25 providing input shift registers that can be reconfigured to produce the same net parallel throughput independently of the serial bit rate of the input links. There are 8

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serial input links available for input at 2.048 megabits per second operation. At 4.096 megabits per second only the first 4 are used, and at 8.192 megabits per second, only the first 2 are used. Blocking modes are also  
5 available that allow the use of more inputs.

The base input configuration, as used in the 2.048 megabit per second input data rate is shown in Figure 2, which shows serial inputs streams STI0 - STI7 input through redirect circuit 40 to a staggered length set of  
10 input shift registers 31 - 38. These are followed by a set of 8 tristateable latches with parallel data taps 31a - 38a. By staggering the length of the input shift registers, the time at which the input data is ready to be parallel loaded can be effectively delayed, (i.e.  
15 when the output latches are enabled) in turn, from each latch set. The timing of this scheme is such that input stream 0&4 are written to data memory first, followed in sequence by 1 &5, 2&6 and 3&7, all in two 8 bit byte parallel format. This sequence is evident by the  
20 increasing length, and hence the time delay, associated with the ascending input stream pairs. The parallel data is written to the low (MSB=0) and high (MSB=1) halves of the data memory, allowing the use of only four write cycles in one internal channel cycle, based on the  
25 internal timing shown in Figure 1.

With input data at 4 megabits per second, the circuit operates without changing the base set of input registers seen in Figure 2, and within the constraints of the internal data memory write and read cycle timing as

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shown in Figure 1. This is accomplished by redirecting the input streams to new sets of input latches, with the proper number of delay registers to align them with the internal enable / write timing pulses. This redirection

5 for the 4 megabits per second mode is shown in Figure 3. The input sftm STIO continues into the first set of latches, while the input stream STI1 is redirected down one set, the input stream STI2 is redirected down two sets, and the input stream STI3 is redirected down three

10 sets. This allows the data memory write cycles to remain in the same spot in the overall timing scheme, with only a minor modification to the coding of the input load pulses themselves. Instead of loading in an ascending pair sequence, the data is loaded from input latch sets

15 0&4, and then from 2&6 in a repeating sequence. Within a single internal 3.91 microsecond channel (32 of these in an internal 125 microsecond frame) there are 4 internal write cycles, but now the write data are loaded from latch sets 0&4 and 2&6 twice each, in the sequence

20 0&4,2&6,0&4,2&6. This necessitates a retiming of the output enable strobes of the input registers.

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Referring now to Figure 4, for an 8 megabits per second input mode, only two input links are used, and these are redirected. The internal memory timing must be

25 kept consistent, and the way the input data is latched and loaded adjusted to compensate for the change in serial input data rate. By redirecting the input stream to the latch set 4, load latch sets 0&4 can be parallel loaded repeatedly (4 times per internal channel) and



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thereby the 8 megabits per second incoming data accommodated, with a consistent internal timing structure. The loading sequence is simply a repetition of 0&4,0&4,0&4,0&4 for one internal 3.91 microsecond  
5 channel. Of course, for all of these different modes, unique input shift register clocks must be generated to properly shift the input data at the desired data rate.

The output latch sets undergo a similar mapping strategy to accommodate the variable output rates in both  
10 standard and rate conversion modes. The output loads also base their timing on the internal data memory timing cycle seen in Figure 1, with 8 output register loads in one internal channel. These occur during the period labeled "data memory internal read accesses" in Figure 1.  
15 With 32 internal channels in one frame, and 8 output loads per channel, the desired 256 bytes of output data are achieved in one 125 microsecond frame. The base 2 megabit per second output configuration is seen in Figure 5. The output register sets consist of 8 bit loadable  
20 shift registers 51 - 58 followed by a variable length set of buffer registers. The variable length buffer registers play no part in the base 2 megabits per second mode. For this mode, the data is effectively loaded directly in to the "load & delay" section 51 - 58 and streams out with  
25 no additional delay. The staggered set of output registers are necessary to ensure that the data for each output stream aligns properly with the data stream channel boundary. The output of registers 61-68 passes to

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output redirect circuit 70, where it emerges as 8 serial output streams ST00-ST0-7.

It is evident from the decreasing number of register buffers added to the respective streams, which latch set  
5 is loaded first. The base loading sequence is 0,1,2,3,4,5,6,7, with the additional buffers delaying the channels that were loaded earlier, to force alignment with the output channel boundary.

In 4 megabits per second output operation, shown in  
10 Figure 6, with external serial 8 bit channel times of 1.95 microseconds (8 x 244 nanoseconds), extra delay elements are introduced in the "load & delay" block. The buffer registers are necessary to align the output channel data with the external output channel boundaries,  
15 consistent with the internal data memory read timing. For 4 megabits per second mode, the output data streams are delayed by eight additional 4.096 Mhz output shift clock cycles, aligning the data with the external output channel timing. In addition, the data streams are  
20 redirected as necessary to align each loaded PCM byte to its respective link and channel boundary. The same internal load pulses are used, but the load enables are modified to load each latch set twice in one internal 3.91 microsecond channel. The load sequence is  
25 0,2,4,6,0,2,4,6. This accommodates the 4 megabits per second output data rate while allowing the internal memory access and shift register load pulse timing to remain unchanged.

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For an 8 megabits per second output mode (Figure 8), a similar reconfiguration occurs. In order to align the outgoing data streams with the internal cycle timing, delay the loaded output data must be delayed by twenty-  
5 four additional 8.192 Mhz output shift clocks by default, instead of the 8 output clock cycles for the 4 megabits per second mode. The reasons for this are apparent from an inspection of Figure 7. The output streams must be delayed by the appropriate number of additional cycles to  
10 align with the channel boundary. This is achieved by loading output latch sets 1 and 5, and redirecting the resulting data streams. The output load sequence in one internal channel is 1,5,1,5,1,5,1,5. This allows the 8 megabits per second data rate on the two output streams  
15 to be met within the constraints of the internal timing cycle.

As shown in Figure 7, ST00, channel 4N is loaded at point A, but it cannot come out until point B. This time is shown by the bracket C in the output shift vclock  
20 stream. Consequently,  $7+24 = 31$  buffer flip-flops must be added for alignment, which is why ST10 is redirected to latch set 1 instead of 0.

It is important to note that the architecture of the design allows for independence between the input and  
25 output modes. The input write addressing is based solely on the internal timing, with a variable addressing structure converting the connect memory contents to the appropriate address for output data reads. As well, the connect memory addressing is dependent only on the output

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mode, and is automatically adjusted to compensate for the selected output mode. In this way, the input and output modes are essentially independent, and so are easily reconfigurable around the internal timing, to make

5 backplane as well as rate conversion modes possible. The architecture is also easily extensible, with the simple addition of a new input and output mode decoding, and a slight modification to the load timing circuitry.

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## CLAIMS:-

1. A time division switching matrix capable of effecting rate conversion characterized in that it comprises a plurality of serial inputs for connection to respective serial input links, each capable of carrying time division multiplexed PCM channels, a plurality of serial outputs for connection to respective serial output links, each capable of carrying time division multiplexed PCM channels, and a serial-to-parallel converter associated with each input for converting a serial input stream to parallel format, each said serial-to-parallel converter being independently configurable to produce the same net parallel throughput regardless of the bit rate of the associated input link.
2. A time division switching matrix as claimed in claim 1, characterized in that said serial-to-parallel converters are shift registers.
3. A time division switching matrix as claimed in claim 2, characterized in that said shift registers are of staggered length so as to delay the time when input data is ready to be parallel loaded.
4. A time division switching matrix as claimed in claim 3, comprising means for redirecting the input serial data streams to different shift registers with the required number of delay registers so as to align the input streams with internal enable/write timing pulses.
5. A time division switching matrix as claimed in claim 1, characterized in that it further comprises a parallel-

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to-serial converter associated with each output for converting a parallel input stream to serial format for application to the associated output link, each said parallel-to-serial converter being independently configurable to permit the same net parallel throughput regardless of the bit rate of the associated output link.

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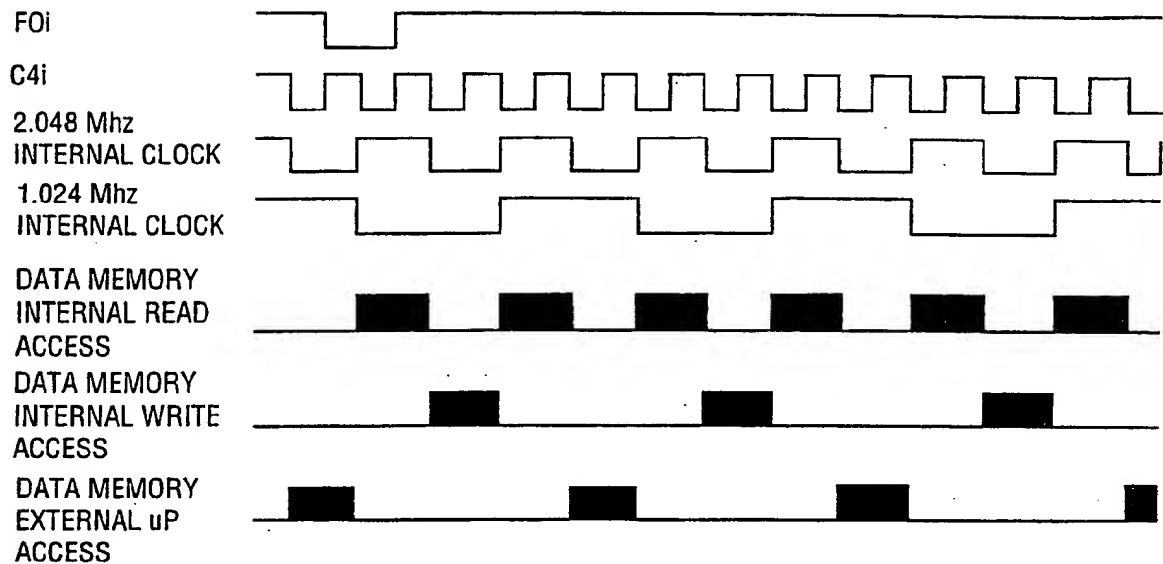


FIG. 1

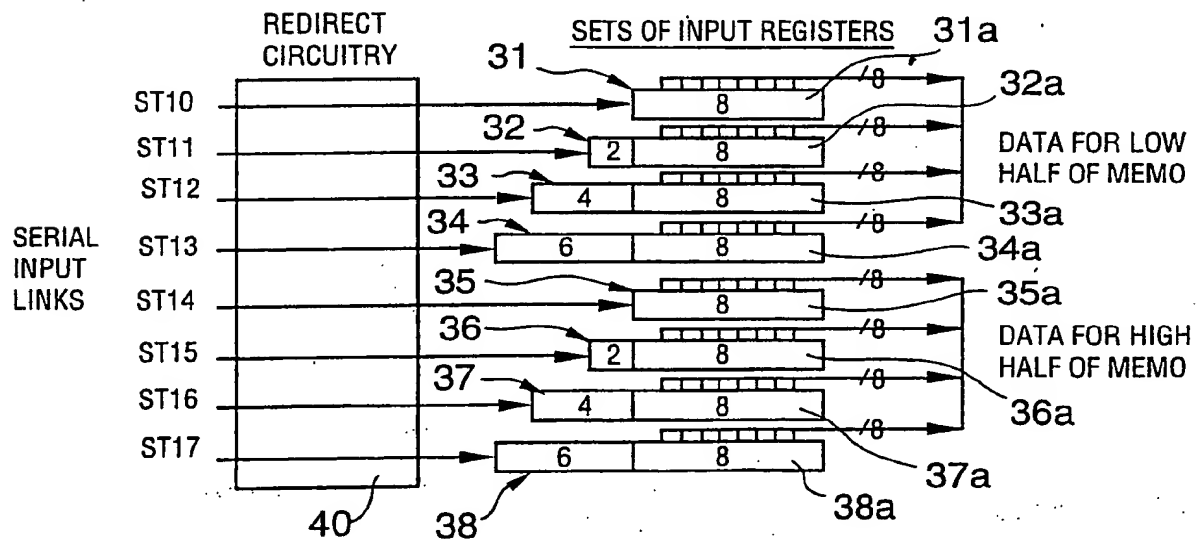


FIG. 2

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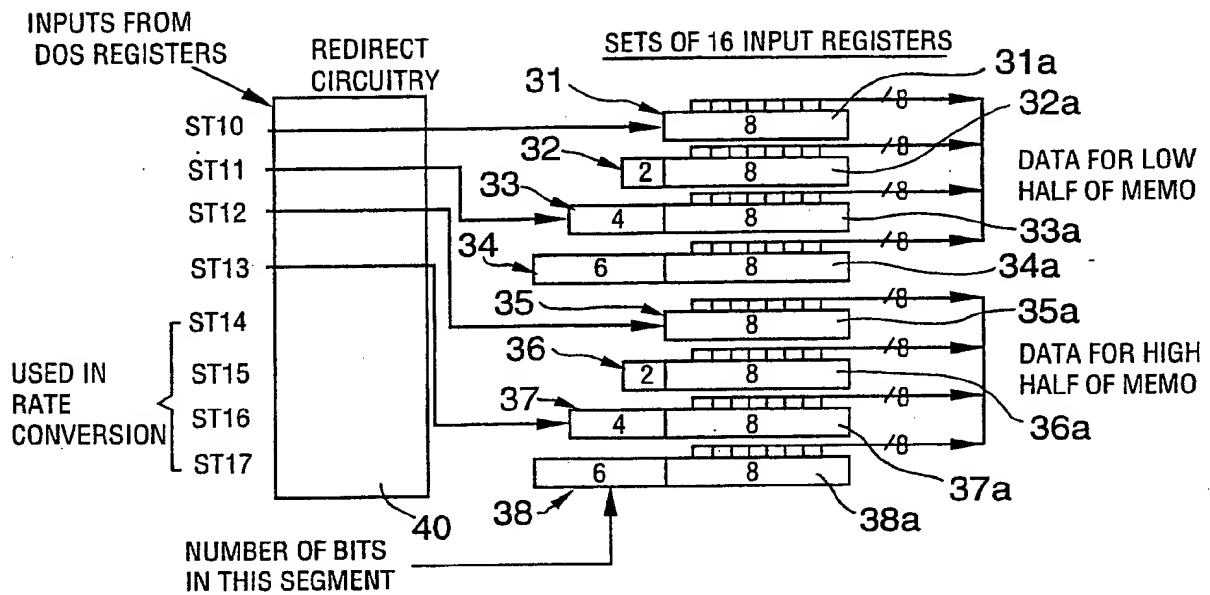


FIG. 3

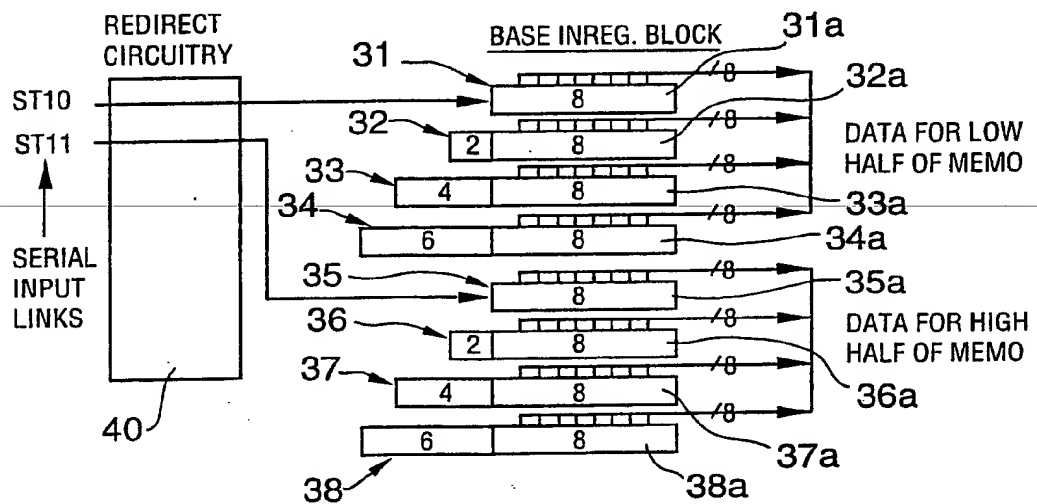


FIG. 4

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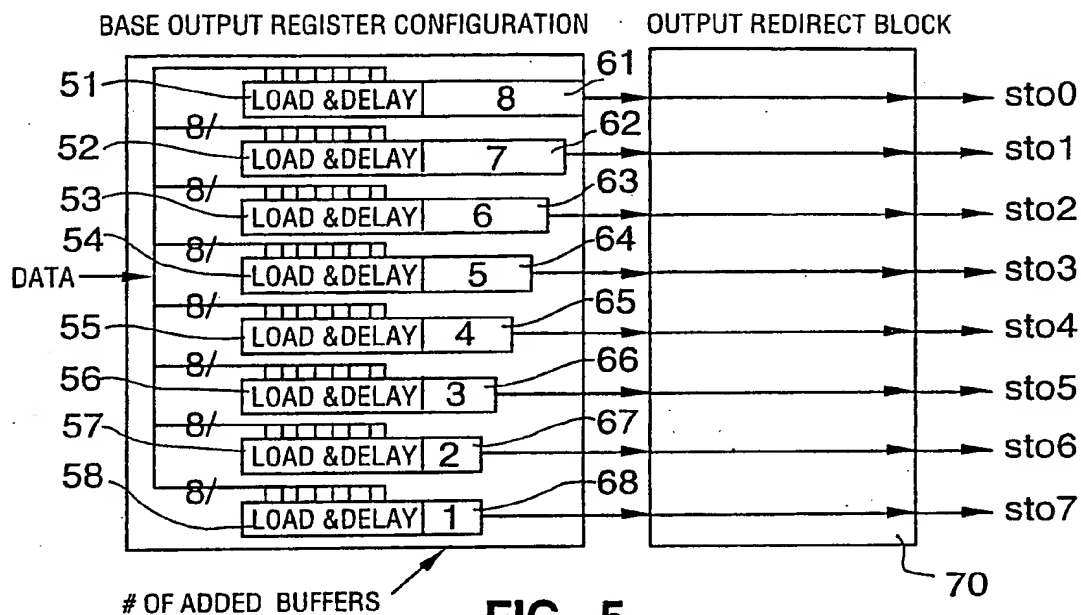


FIG. 5

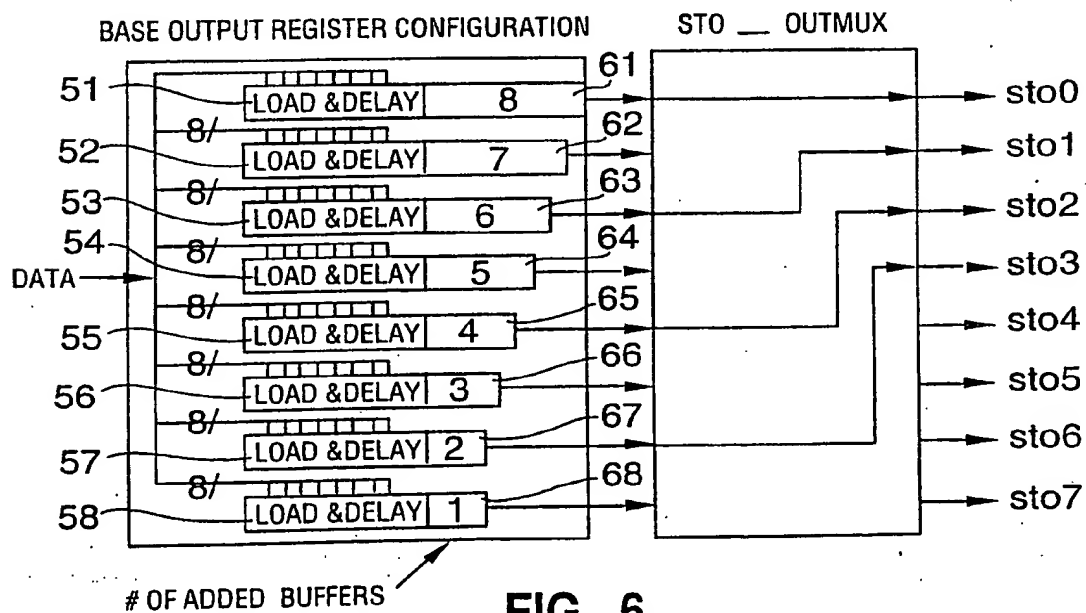


FIG. 6

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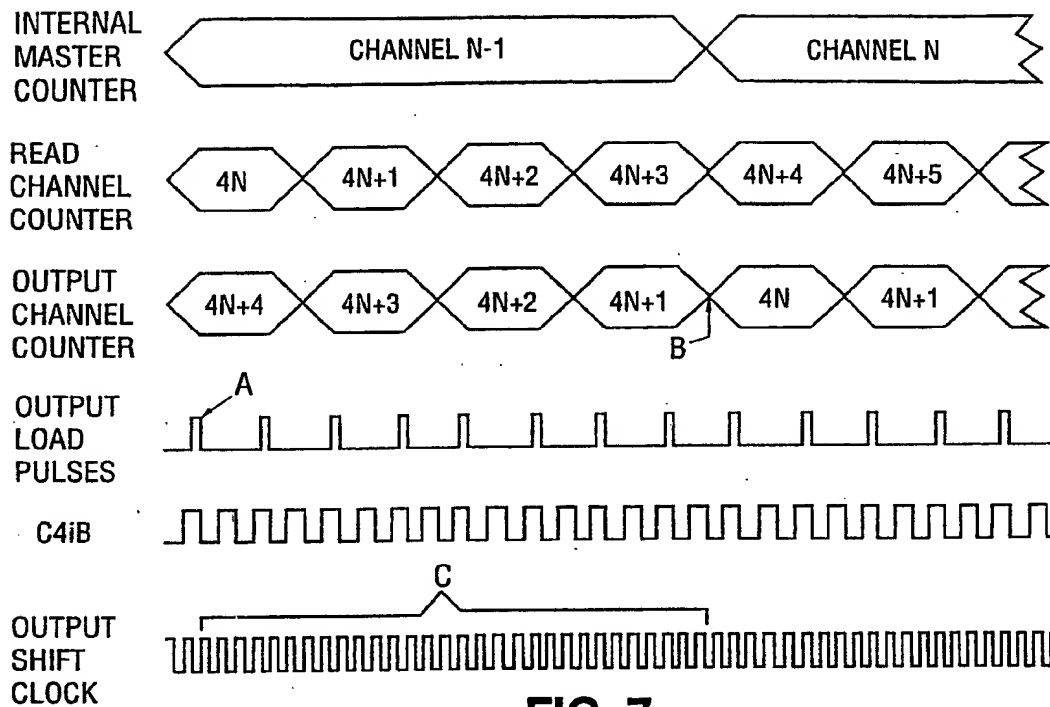


FIG. 7

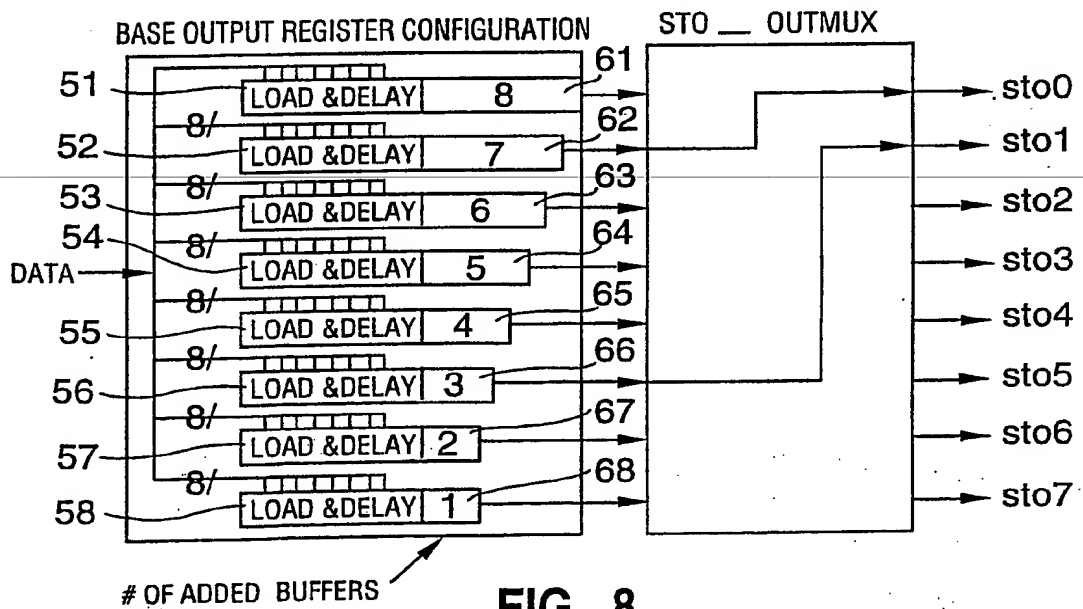
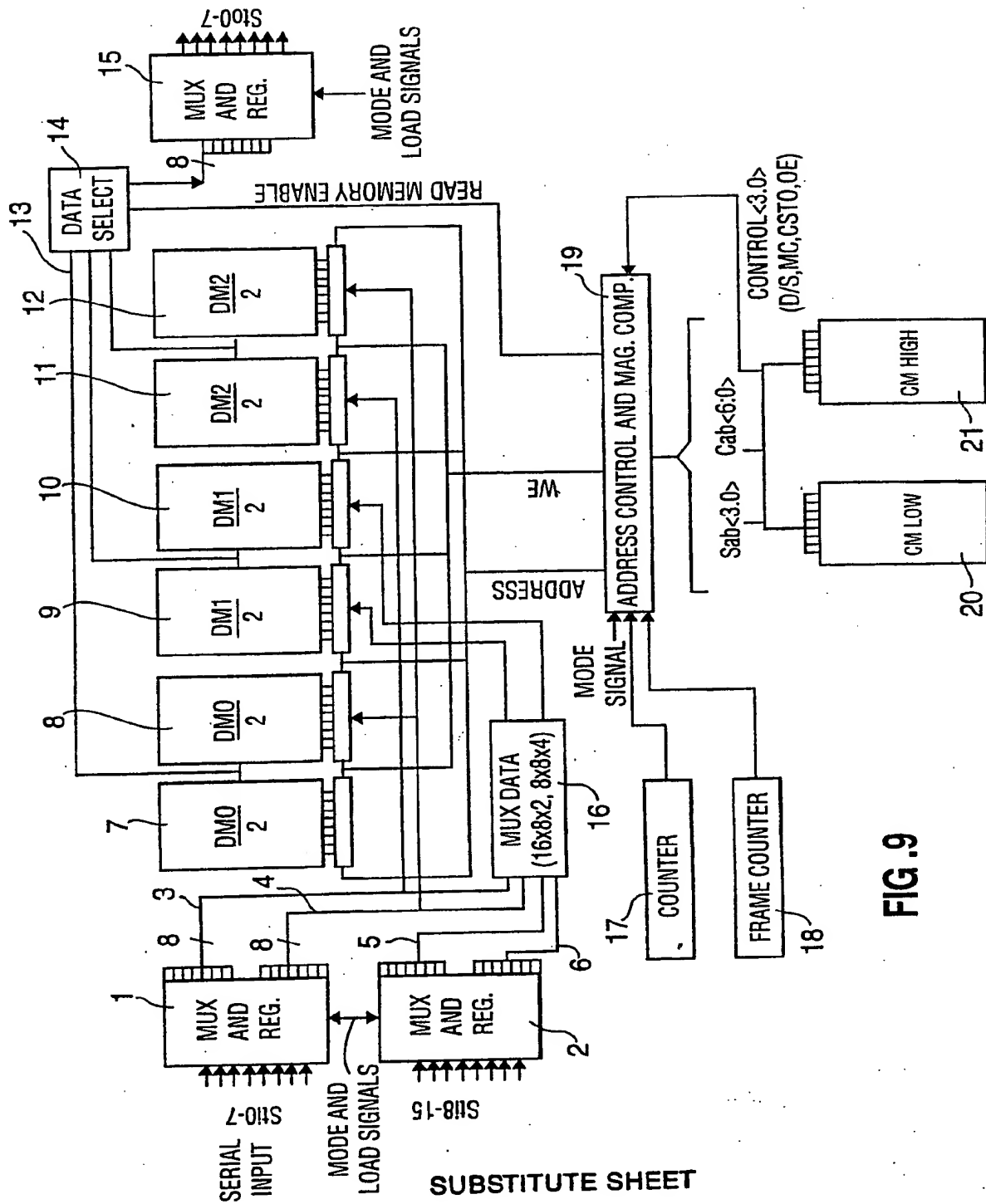


FIG. 8

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## INTERNATIONAL SEARCH REPORT

International Application No  
PCT/CA 94/00377A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 H04Q11/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	FR,A,2 376 572 (A. ROCHE) 28 July 1978 see the whole document ---	1-3,5
A	FR,A,2 265 240 (CGCT-LMT) 17 October 1975 see page 7, line 23 - page 11, line 16 ---	1-3,5
A	US,A,5 060 227 (FINLEY ET AL) 22 October 1991 see column 1, line 8 - line 13 see column 4, line 45 - column 5, line 4 see column 6, line 43 - line 45 see column 7, line 20 - line 41 see column 8, line 41 - line 59 --- -/--	1,5

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A	<p>EP,A,0 453 129 (AT&amp;T) 23 October 1991 see claims 1-19</p> <p style="text-align: center;">---</p>	
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Information on patent family members

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